National Urbanization Monitoring Assessment (NUMA)

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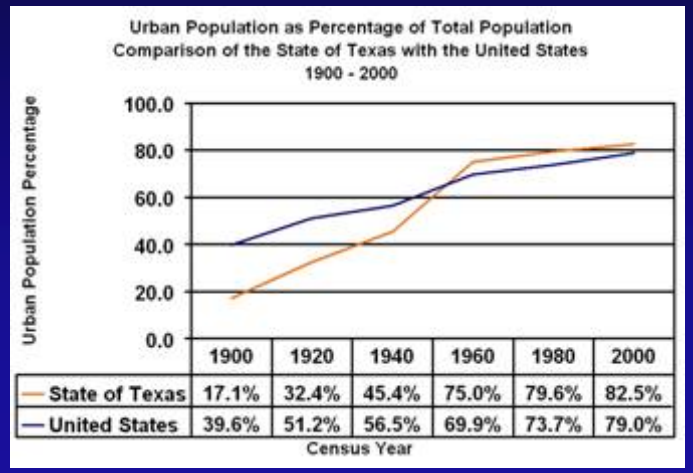
U.S. Geological Survey

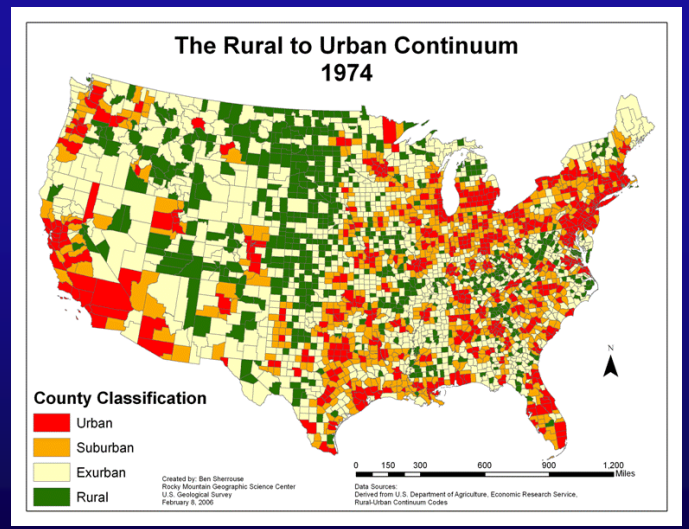
NUMA Geographic Perspective

- Five Themes of Geography
  - Location
    - People, Places, Time, Direction, and Distance
  - Places
    - Human and Physical characteristics
  - Human-Environmental Interactions
    - Humans modify the environment
    - Humans depend on the environment
  - Movement
    - People, Goods, and Ideas
  - Regions
    - Formal, Functional, and Perceived

NUMA Research Issues

- U.S. Population composition becoming increasingly more urban
- Urban land growth rate exceeding urban population growth
- Majority of urban growth spreading into rural landscapes
- Relatively cheap agricultural land encourages development on the urban fringe





Research Assumptions

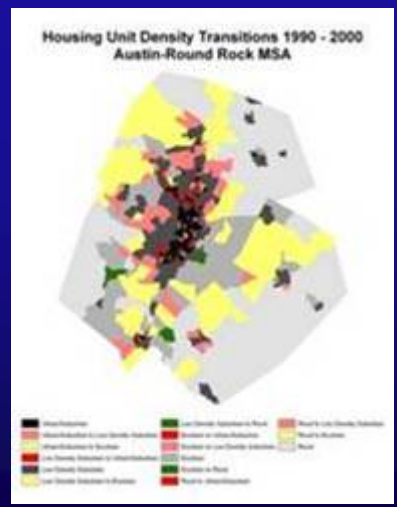
- Metropolitan areas continue to be the economic engines driving regional urbanization
- Urban form follows densification thresholds and infrastructure development
- Urbanization is occurring faster in exurbia as compared to rural, suburban, & urban areas
- Regions with the highest socioeconomic and demographic growth rates should be the fastest urbanization engines

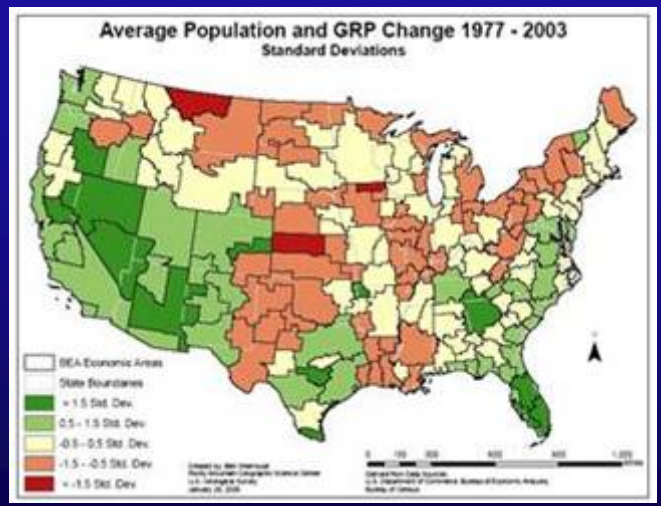
Fastest growing economies

RANKING BASED ON GROWTH RATE OF GMP*

RANK	METRO AREA	IN U.S. BILLIONS 1990	2000	INCREASE
1.	Las Vegas, NV	20.5	54.6	166.3%
2.	Austin-San Marcos, TX	18.8	48.2	156.4%
3.	Laredo, TX	2.7	6.6	144.4%
4.	Provo-Orem, UT	3.4	8.3	144.1%
5.	Boise, ID	5.9	14.4	144.1%
6.	Phoenix-Mesa, AZ	47.3	114.2	141.4%
7.	Colorado Springs, CO	7.3	17.6	141.1%
8.	Myrtle Beach, SC	2.9	6.9	137.9%
9.	Fort Collins-Loveland, CO	3.5	8.3	137.1%
10.	Greeley, CO	2.2	5.2	136.4%
11.	Yolo, CA	3.9	8.9	128.2%
12.	Albuquerque, NM	11.3	25.6	126.5%
13.	Yuma, AZ	1.2	2.7	125.0%
14.	Corvallis, OR	1.2	2.7	125.0%
15.	Atlanta, GA	73.4	164.2	123.7%
16.	Grand Junction, CO	1.7	3.8	123.5%
17.	Sioux Falls, SD	3.6	8.0	122.2%
18.	Boulder-Longmont, CO	5.4	12.0	122.2%
19.	Salt Lake City-Ogden, UT	21.1	46.4	119.9%
20.	Fayetteville-Springdale-Rogers, AR	4.1	9.0	119.5%

* GROSS METROPOLITAN PRODUCT





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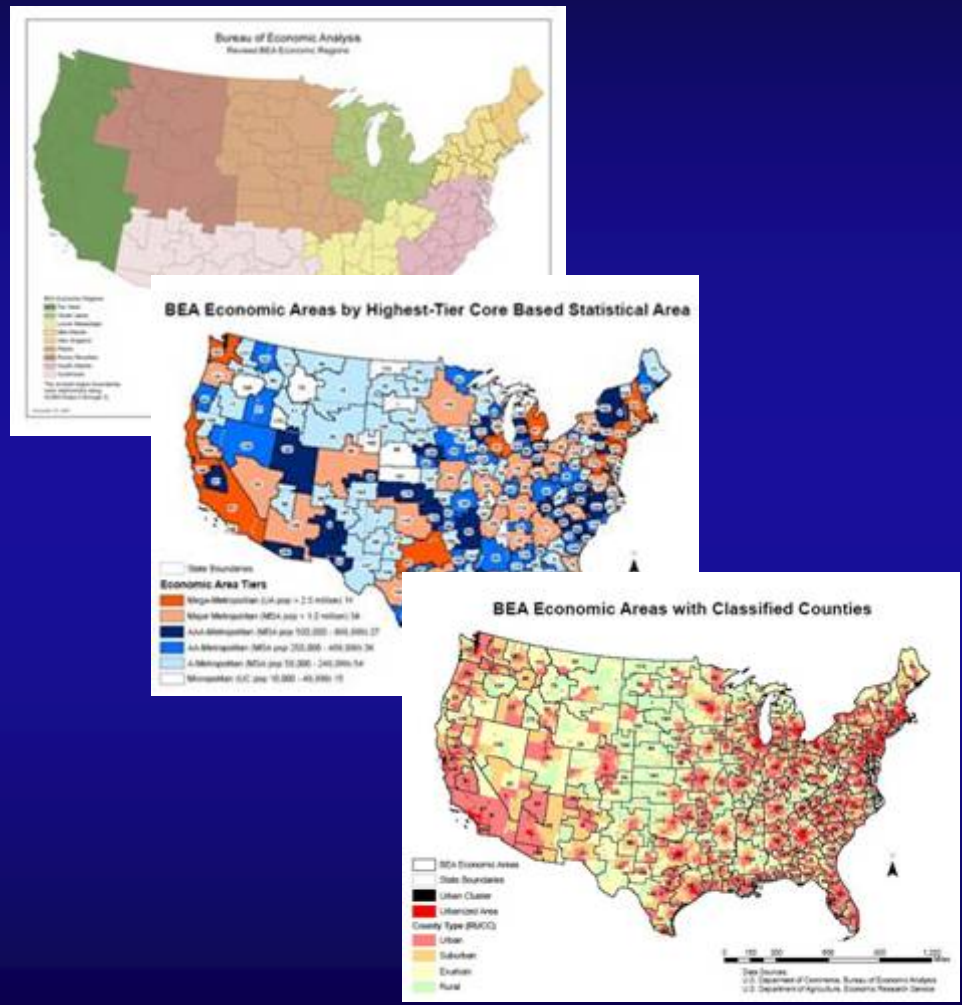
Research Hypotheses

- Do urban growth rates, urban form patterns, and land use transitions vary between Economic Areas?
- Does urbanization vary depending on the primary Core-Based Statistical Area within an Economic Area?
- Can land use transition probabilities be used to forecast rural-to-urban transformations?
- Are specific Economic Areas and urban forms causing greater ecological and societal impacts?



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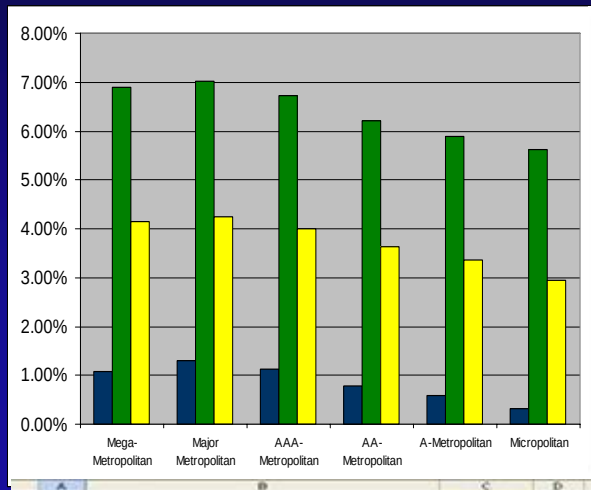
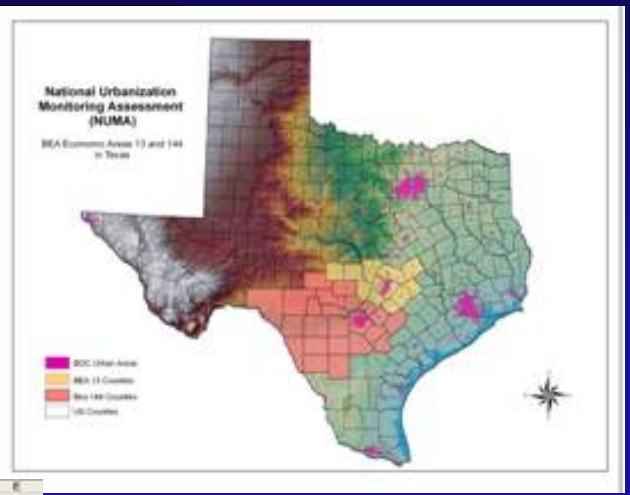
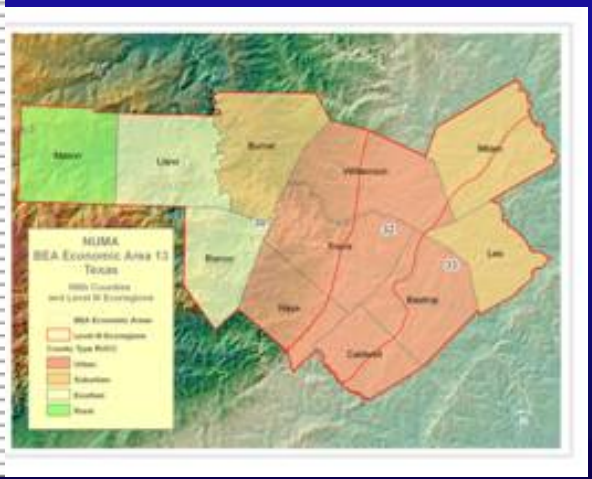
Research Methodology

- Classify Economic Areas based on Core-Based Statistical Area tiers
- Stratify Economic Areas using Average Population/Gross Regional Product rates
- Select Areas of Interest
  - Austin and San Antonio, Texas Economic Areas
- Subdivide Economic Areas
  - Rural-to-Urban Continuum Codes
- Extract indicators from Metrics database
- Conduct Land Use Trend Analysis and compute Human migratory paths





	A	B	C	D	E
1	%Code	EAName	PopGRPAvgRank	PopRank	GRPRank
2	92	Las Vegas-Paradise-Pahrump, NV	1	1	1
3	146	Sarasota-Bradenton-Venice, FL	2	2	2
4	12	Austin-Round Rock, TX	3	3	3
5	128	Phoenix-Mesa-Scottsdale, AZ	4	4	4
6	121	Orlando-The Villages, FL	5	5	5
7	104	McAllen-Edinburg-Pharr, TX	6	6	15
8	136	Reno-Sparks, NV	7	8	12
9	57	Fayetteville-Springdale-Rogers, AR-MO	8	10	7
10	17	Bend-Prineville, OR	9	7	22
11	11	Atlanta-Sandy Springs-Gainesville, GA-AL	10	14	6
12	36	Colorado Springs, CO	11	15	8
13	140	Sacramento--Arden-Arcade--Truckee, CA-NV	12	9	19
14	106	Miami-Fort Lauderdale-Miami Beach, FL	13	11	13
15	58	Flagstaff, AZ	14	16	10
16	145	San Diego-Carlsbad-San Marcos, CA	15	24	11
17	164	Tampa-St. Petersburg-Clearwater, FL	16	22	16
18	169	Tucson, AZ	17	18	24
19	42	Dallas-Fort Worth, TX	18	13	28
20	82	Gainesville, FL	19	23	21
21	46	Denver-Aurora-Boulder, CO	20	25	20
22	21	Boise City-Nampa, ID	21	12	33
23	142	Salt Lake City-Ogden-Clearfield, UT	22	21	27
24	49	Dover, DE	23	44	9
25	157	Seattle-Tacoma-Olympia, WA	24	26	25
26	79	Jacksonville, FL	25	28	23
27	31	Charlotte-Gastonia-Salisbury, NC-SC	26	34	17
28	133	Raleigh-Durham-Cary, NC	27	36	14
29	126	Pensacola-Ferry Pass-Brent, FL	28	33	26
30	115	Myrtle Beach-Conway-Georgetown, SC	29	38	18
31	75	Houston-Baytown-Huntsville, TX	30	20	40
32	147	Santa Fe-Espanola, NM	31	32	31
33	123	Panama City-Lynn Haven, FL	32	42	30
34	61	Fresno-Madera, CA	33	17	56
35	144	San Antonio, TX	34	30	37
36	163	Tallahassee, FL	35	45	29
37	56	Farmington, NM	36	19	50
38	5	Albuquerque, NM	37	27	44
39	149	Savannah-Hinesville-Fort Stewart, GA	38	43	32



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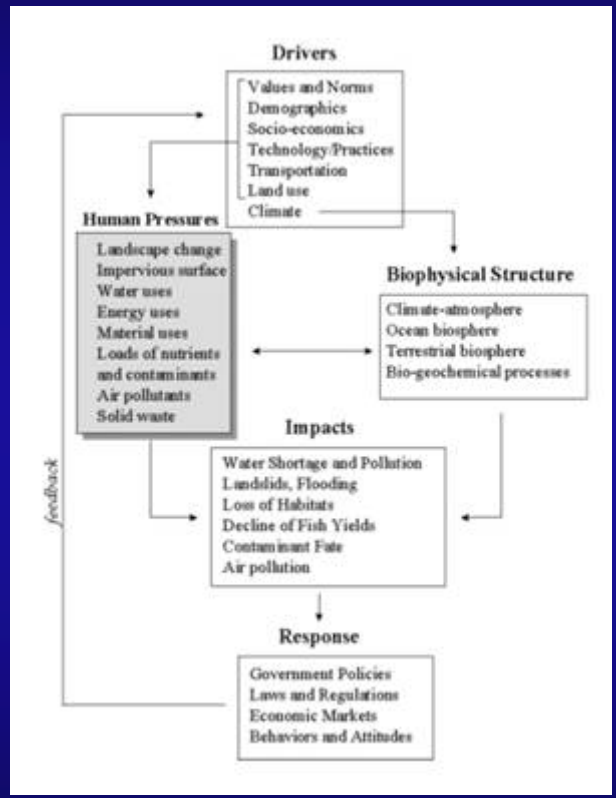
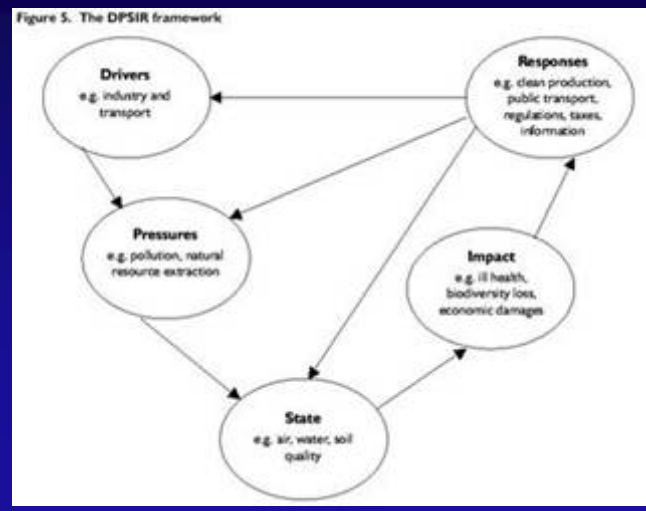
FY06 Project Funding

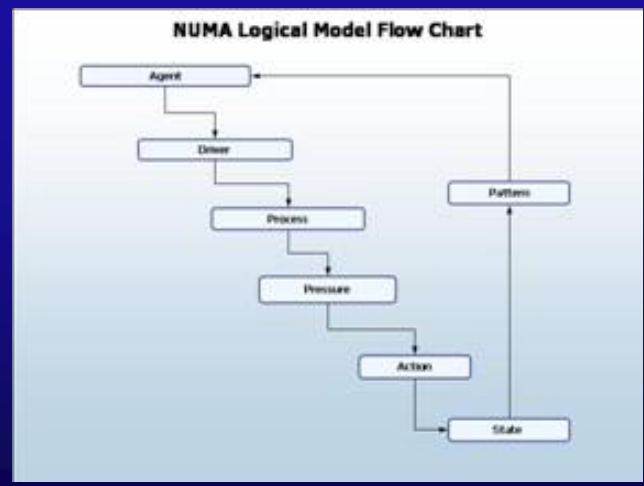
- NUMA Budget
  - Geographic Analysis and Monitoring SIR
    - $381K Total
      - $255K: Government FTE Salaries
      - $76K: SAIC Contractor
      - $10K: Discretionary Operating Expenses
      - $41K: RMGSC Overhead Cost Assessment
  - Edwards-Trinity CR Integrated Science Partnership
    - $10K Geography allocation
- NUMA Team
  - RMGSC (3) Government FTE's and (1) SAIC Contractor
- GAM NUMA Statement of Intent
  - (5) Geographic Research Subtasks

Urbanization Logical Model

- Agent
- Driver
- Process
- Pressure
- Action
- State
- Pattern







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Monitoring Urbanization

- Physical Urbanization Model
- Inventoried ~2600 indicators for monitoring landscape change
- Created Metrics Access database
- Provide capability to query Metrics database for urbanization monitoring indicators

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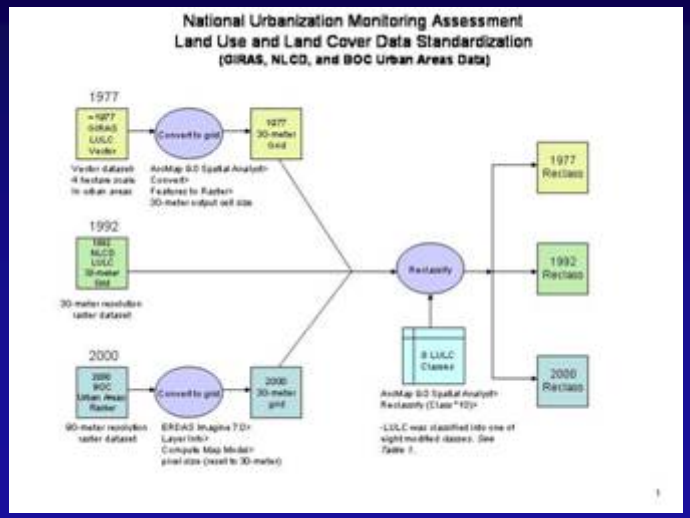
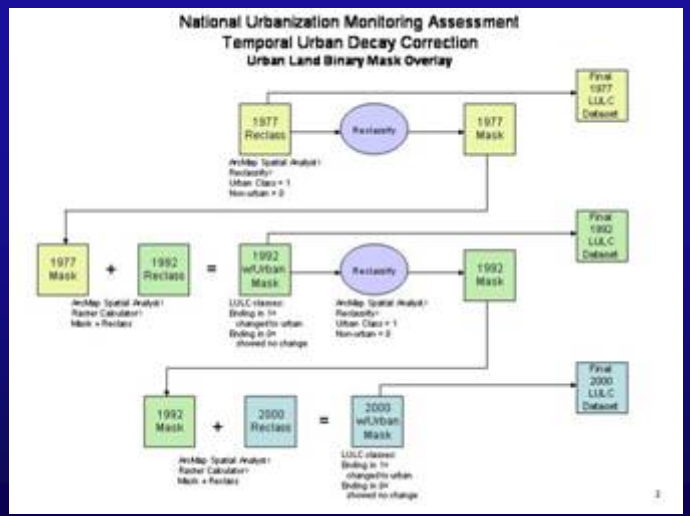
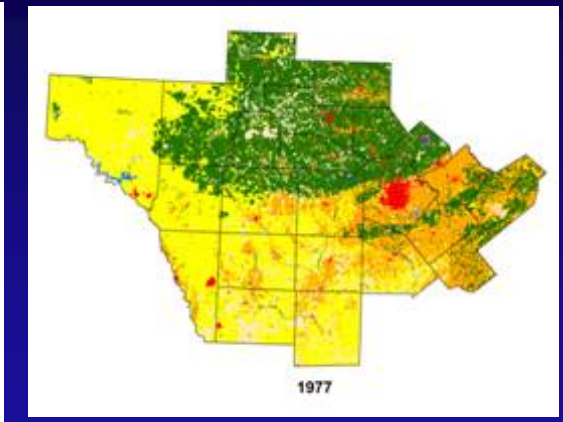
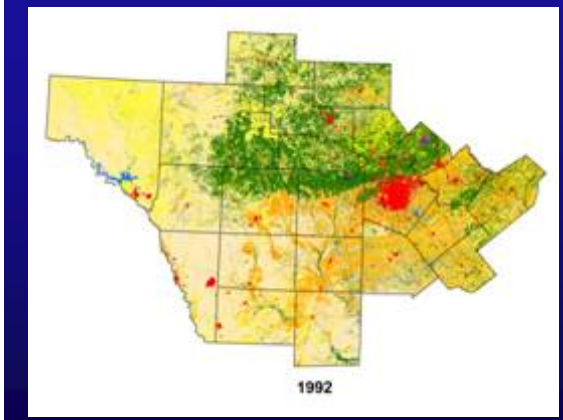
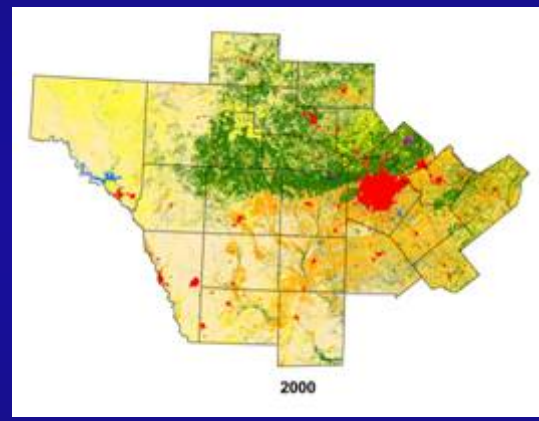
Land Use Trend Analysis



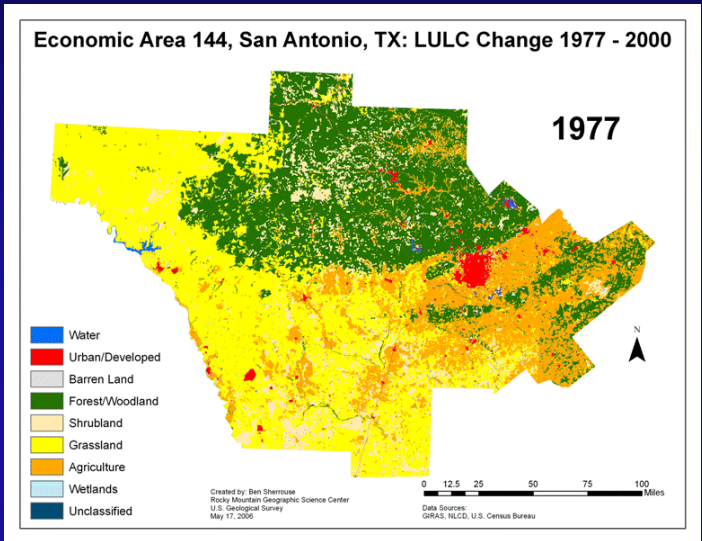


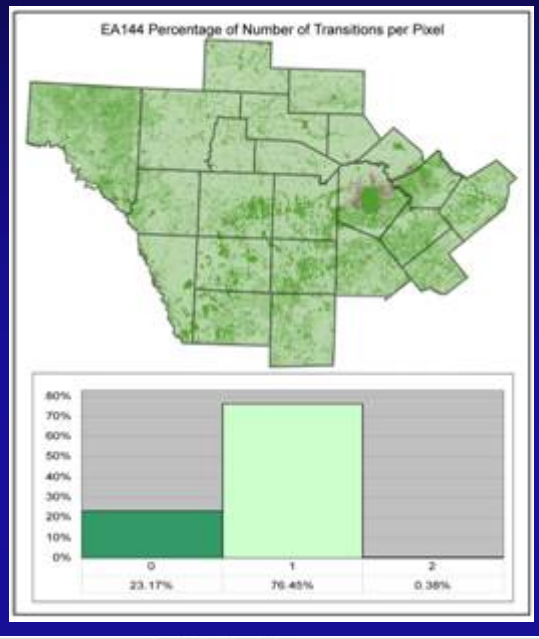


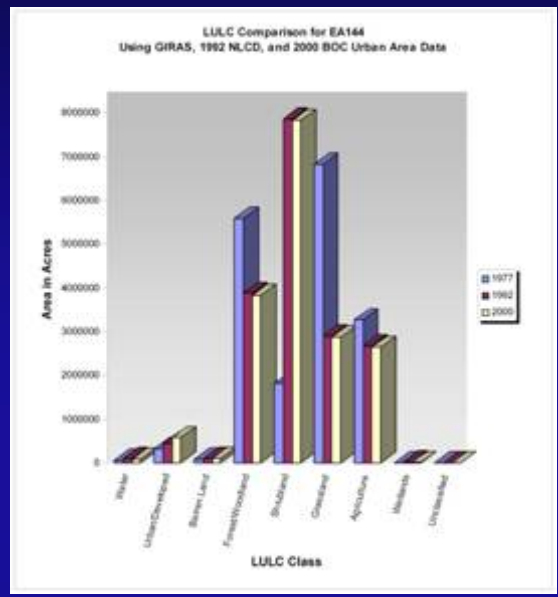


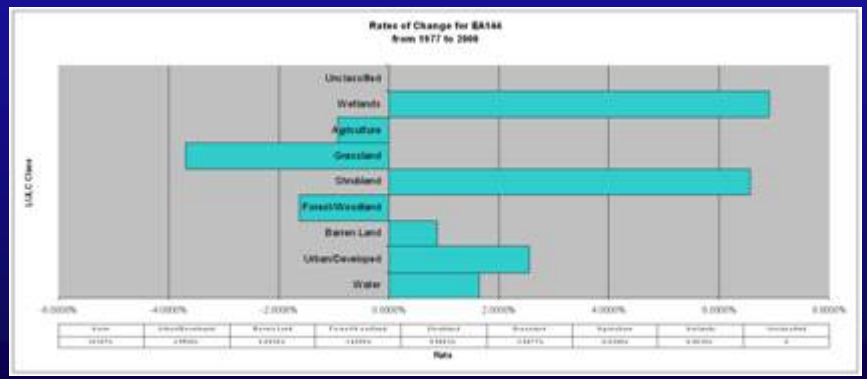


Land Use Trends – San Antonio









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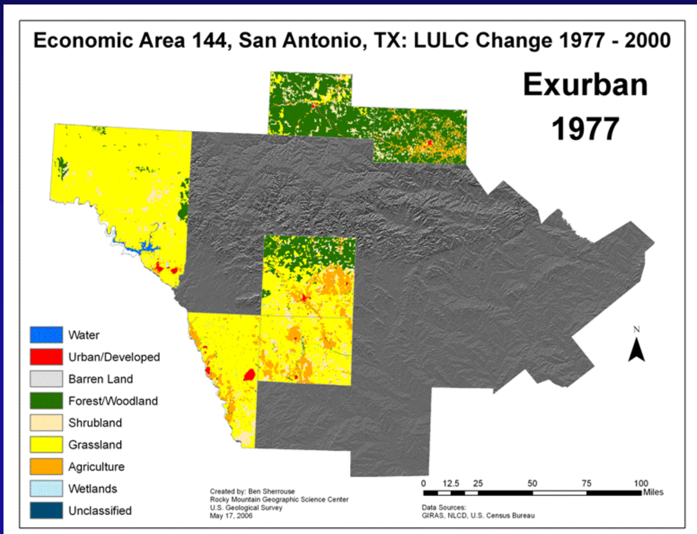
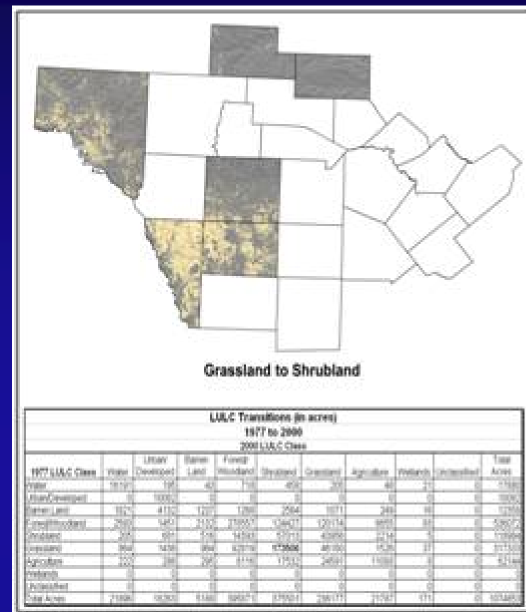
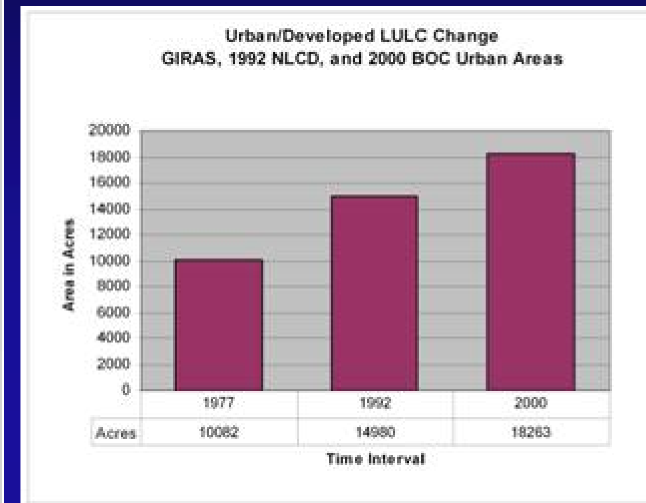
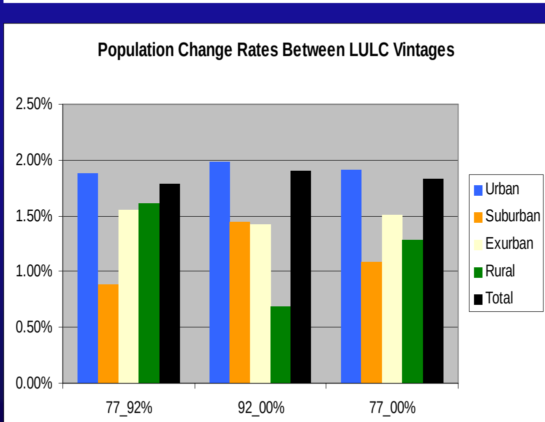
Land Use Trends – Exurban (San Antonio)



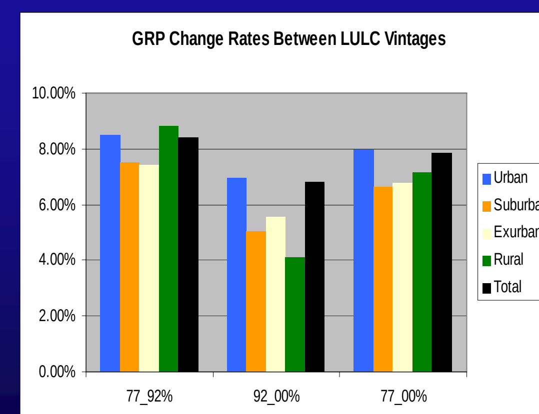


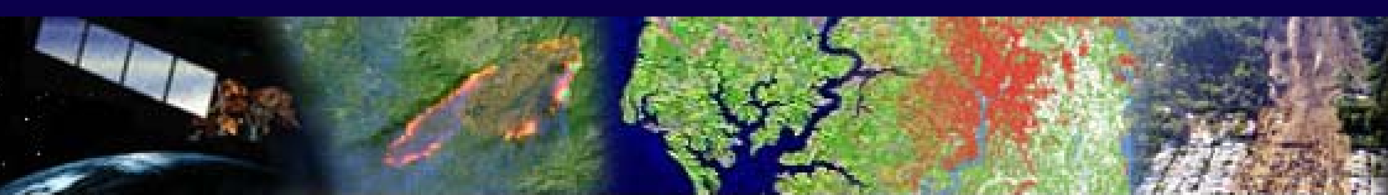




EA13 Exurban RHCC LULC Transitions
Probabilities
1977 to 2000

LULC Classes	Water	Urban/ Developed	Barren Land	Forest/ Woodland	Shrubland	Grassland	Agriculture	Wetlands	Unclassified	Total
Water	0.01506340	0.00018187	0.00004014	0.00066799	0.00040523	0.00019036	0.00004611	0.00001986	0.00000000	0.01663464
Urban/Developed	0.00000000	0.00937989	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00937989
Barren Land	0.00169456	0.00384411	0.00115123	0.00117978	0.00238684	0.00099625	0.00023153	0.00001446	0.00000000	0.01149778
Forest/Woodland	0.00241211	0.00136006	0.00198361	0.25915819	0.11576158	0.11180471	0.00619188	0.00007759	0.00000000	0.49873973
Shrubland	0.00019056	0.00063366	0.00048002	0.01339097	0.05304249	0.04089482	0.00206017	0.00000497	0.00000000	0.11069755
Grassland	0.00080404	0.00133579	0.00089715	0.08635503	0.16142290	0.04296430	0.00142000	0.00003455	0.00000000	0.29623375
Agriculture	0.00020891	0.00026608	0.00027477	0.00755084	0.01631146	0.02287866	0.01033069	0.00000724	0.00000000	0.05781666
Wetlands	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Unclassified	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
Total	0.02037158	0.01699135	0.00482692	0.36830250	0.34935050	0.21972909	0.02029937	0.00015870	0.00000000	1.00000000





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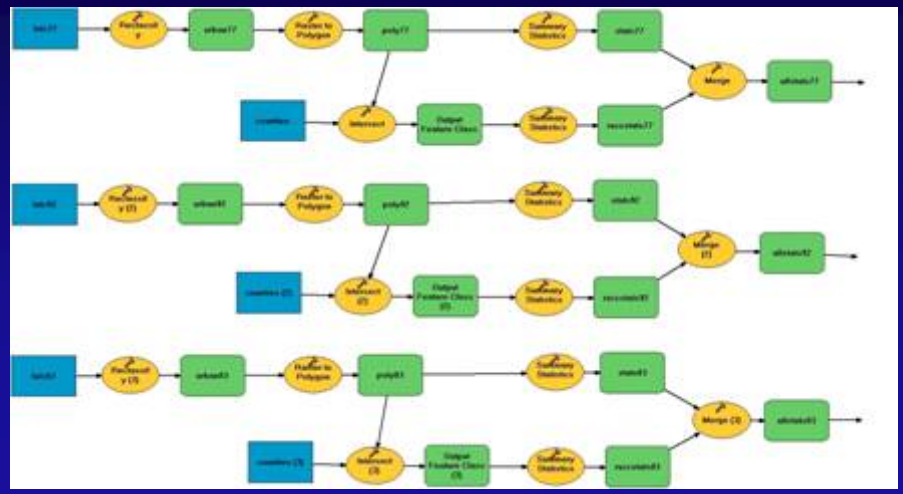
Human-Induced Land Transformations

- Developed a statistical module to analyze temporal urban form characteristics
- ArcGIS Model Builder and Excel emulate SLEUTH and FRAGSTATS metrics



Urban Land Metrics

Economic Area 13 – Austin-Round Rock, Texas

	Number of Urban Clusters			Urban Edge Length (meters, thousands)			Urban Cluster Area (square meters, in Ekms)			Average Urban Cluster Size (square meters, thousands)			Urban Aggregation Index		
RUCC Category	1977	1992	2000	1977	1992	2000	1977	1992	2000	1977	1992	2000	1977	1992	2000
All	500	13,458	11,107	2,465	7,806	6,201	698	954	1,556	1,395	71	140	0.029	0.060	0.033
Urban	159	8,075	5,840	1,836	5,470	4,009	571	779	1,340	1,392	97	229	0.026	0.058	0.025
Suburban	99	2,804	2,707	372	1,307	1,264	75	102	129	757	36	48	0.039	0.106	0.081
Exurban	54	1,772	1,745	256	827	786	41	60	73	755	34	42	0.049	0.114	0.088
Rural	10	922	922	35	256	256	11	14	14	1,063	15	15	0.019	0.152	0.152

Economic Area 144 – San Antonio, Texas

	Number of Urban Clusters			Urban Edge Length (meters, thousands)			Urban Cluster Area (square meters, in Ekms)			Average Urban Cluster Size (square meters, thousands)			Urban Aggregation Index		
RUCC Category	1977	1992	2000	1977	1992	2000	1977	1992	2000	1977	1992	2000	1977	1992	2000
All	784	32,144	28,539	4,343	13,817	13,222	1,310	1,807	2,323	1,670	56	81	0.027	0.073	0.048
Urban	322	13,085	9,872	2,625	8,400	6,067	896	1,267	1,691	1,716	97	171	0.026	0.056	0.030
Suburban	129	6,714	6,507	967	2,987	2,931	185	250	275	1,432	34	42	0.042	0.108	0.089
Exurban	126	9,446	9,214	691	3,199	3,119	215	273	322	1,703	29	35	0.025	0.097	0.080
Rural	28	3,010	3,010	51	1,194	1,194	14	17	17	509	12	12	0.040	0.273	0.273

Urban Aggregation Index values range from 0.0 to 1.0. Smaller values indicate urban land that is more highly aggregated.

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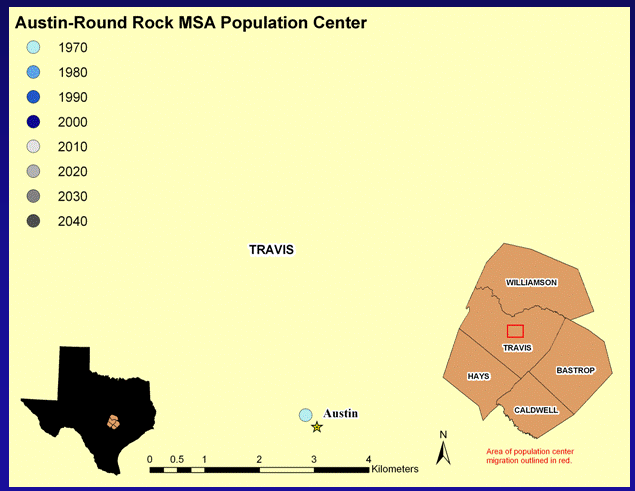
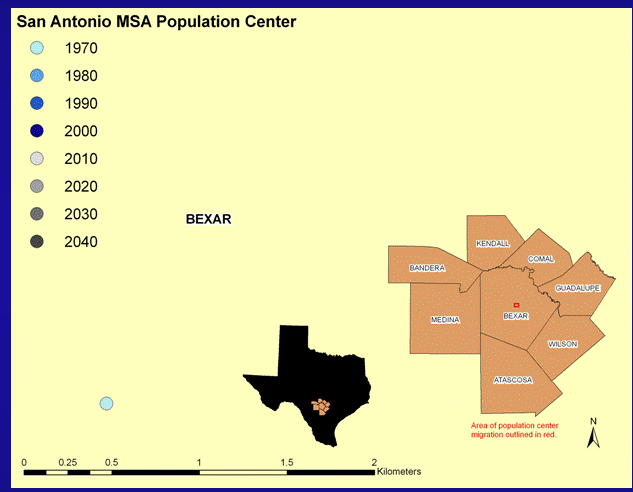
Human Migration - Population

- "Five Themes of Geography"
  - Movement of people, goods, and ideas
- Temporal migration analysis allows monitoring of potential future stress locations



Years Mapped	Mean Center North Latitude (D-M-S)	Mean Center West Longitude (D-M-S)	Migration Distance from Previous Population Center (meters)	Migration Direction from Previous Population Center (bearing - D-M-S)	Annual Population Center Migration Rate (meters)
1970	30-18-29	-97-45-11			
1980	30-19-34	-97-44-55	2,060	N10-27-43E	206.00
1990	30-20-19	-97-44-41	1,423	N15-04-17E	142.30
2000	30-21-07	-97-44-21	1,579	N19-56-02E	157.91
2010*	30-21-16	-97-44-13	348	N32-08-26E	34.81
2020*	30-21-29	-97-44-03	540	N42-25-32E	54.02
2030*	30-21-47	-97-43-43	701	N39-09-33E	70.10
2040*	30-22-04	-97-43-25	719	N40-40-48E	71.93

*projected



Years Mapped	Mean Center North Latitude (D-M-S)	Mean Center West Longitude (D-M-S)	Migration Distance from Previous Population Center (meters)	Migration Direction from Previous Population Center (bearing - D-M-S)	Annual Population Center Migration Rate (meters)
1970	29-27-03	-98-30-19			
1980	29-27-13	-98-30-03	531	N51-45-11E	53.11
1990	29-27-25	-98-29-47	555	N49-05-18E	55.54
2000	29-47-43	-98-29-43	578	N18-30-55E	57.77
2010*	29-27-49	-98-29-33	270	N46-39-46E	26.96
2020*	29-27-56	-98-29-24	337	N48-20-30E	33.66
2030*	29-28-03	-98-29-14	339	N48-51-53E	33.90
2040*	29-28-10	-98-29-05	314	N48-32-26E	31.42

*projected

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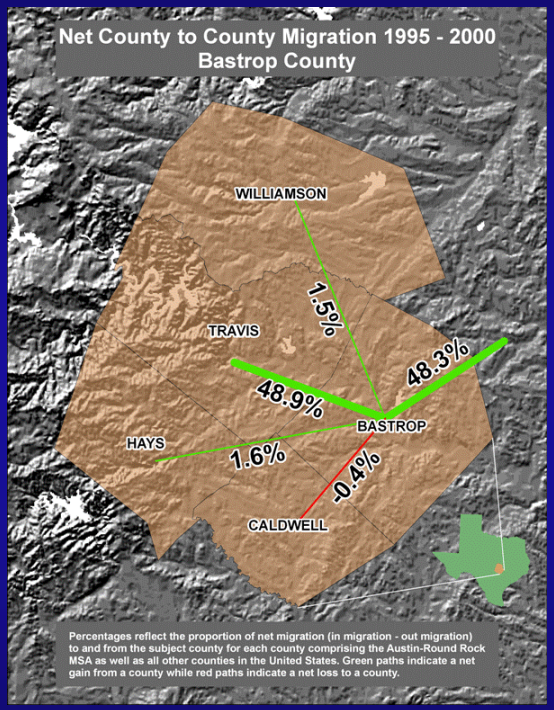
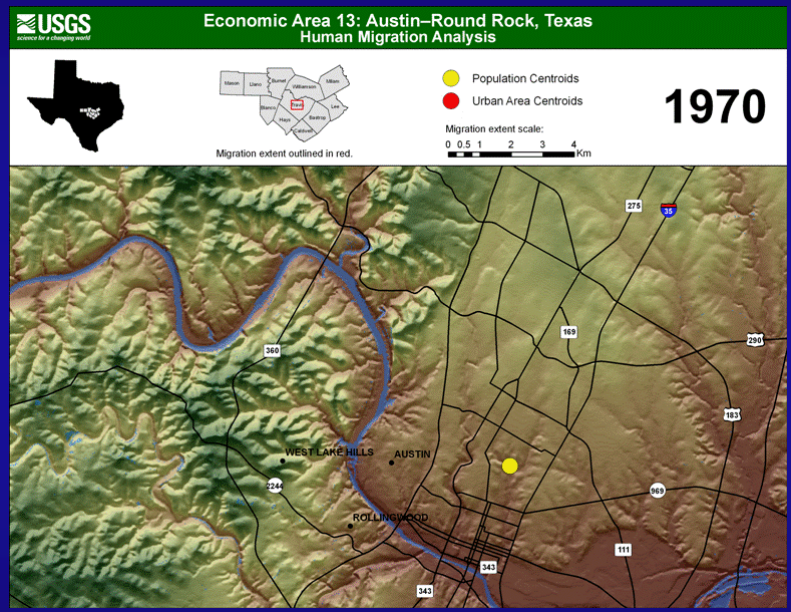
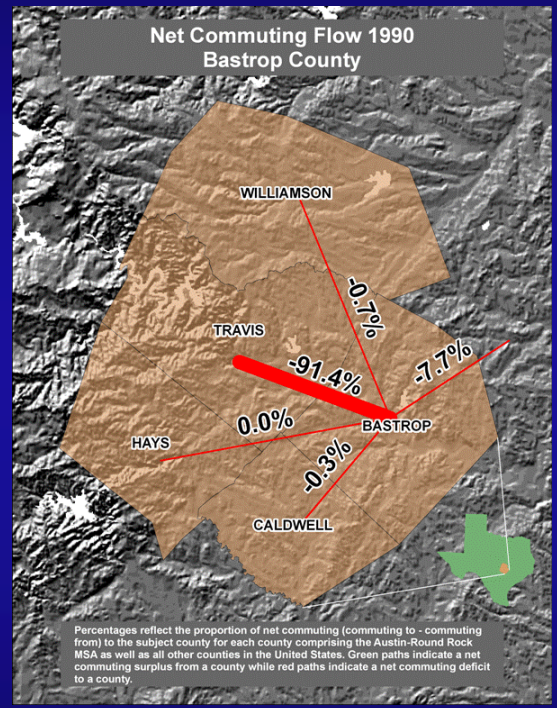
Migration – Urbanized Area & Commuting

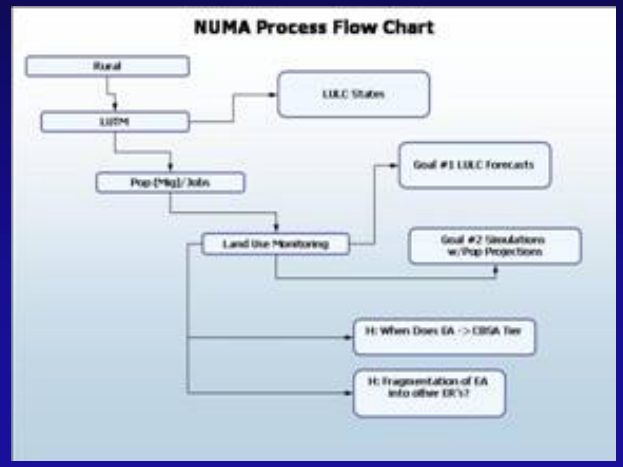


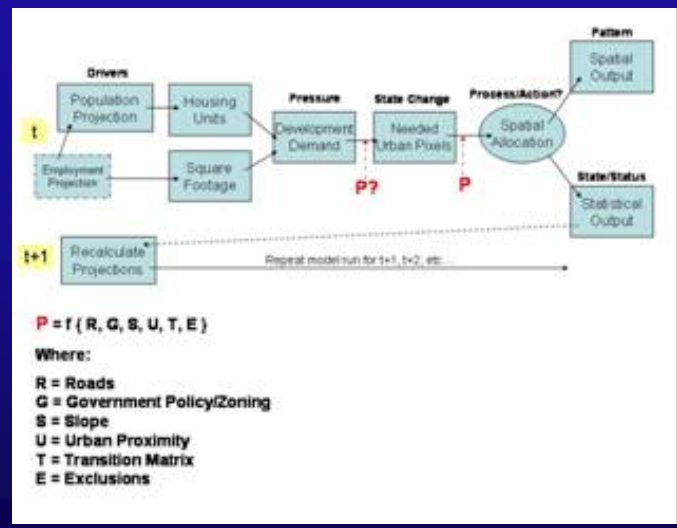




Land Use Modeling

- Investigate estimating and simulating landscape change
- Model would be demand-side driven rather than supply-side (SLEUTH)
- Urbanization as a modeling process follows Logical Data Model architecture





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Urbanization Demands and Impacts

- Water diversions to augment ground-water usage
- Austin and San Antonio traffic congestion
- San Antonio ozone levels
- Land use development on Edwards Aquifer recharge areas
- Value of non-agricultural versus agricultural land
- Endangered species habitat

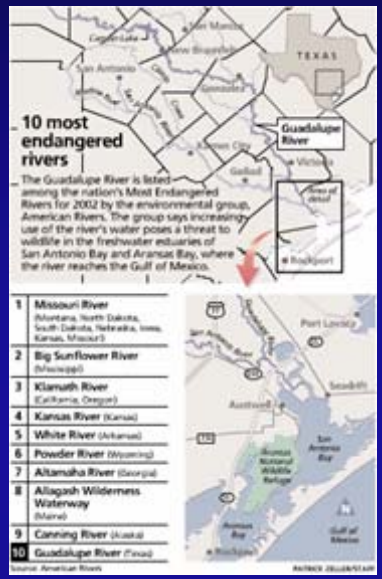


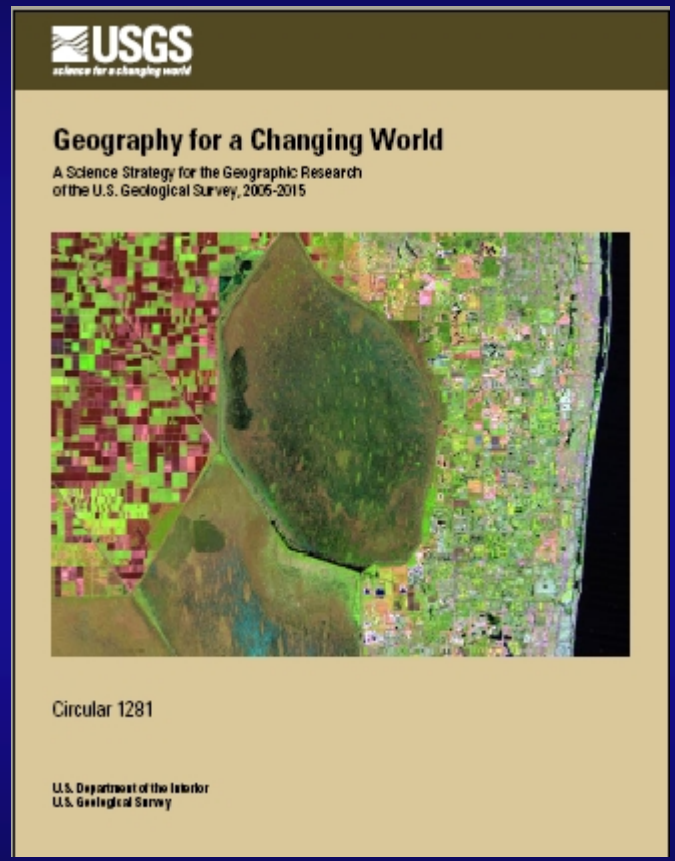
Figure 8: Market Value Change 1992 - 2001

Texas Blind Salamander (*Typhlomolge rathbuni*)

USGS

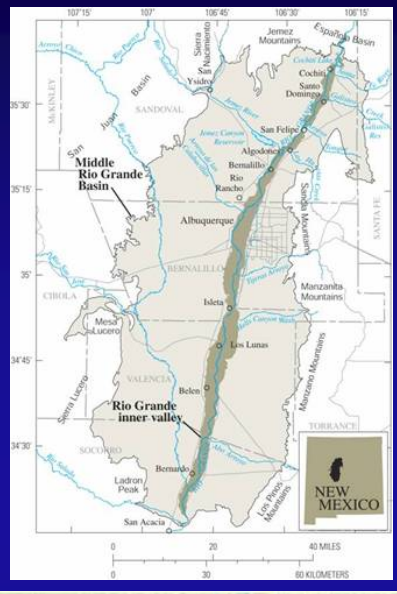
Geography Science Plan

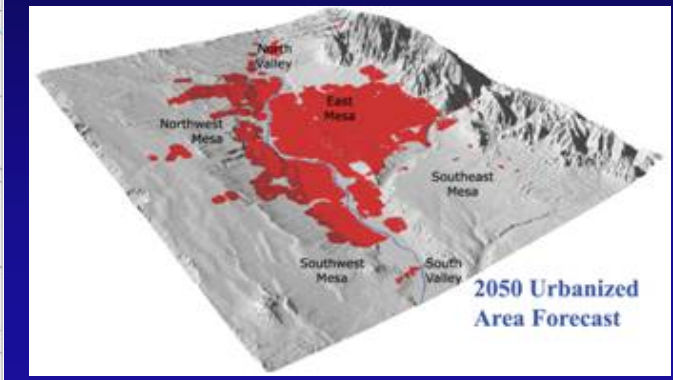
- Geography for a Changing World
  - Strategic Actions
    - 1.6 – develop and implement a strategy for understanding the urban environment

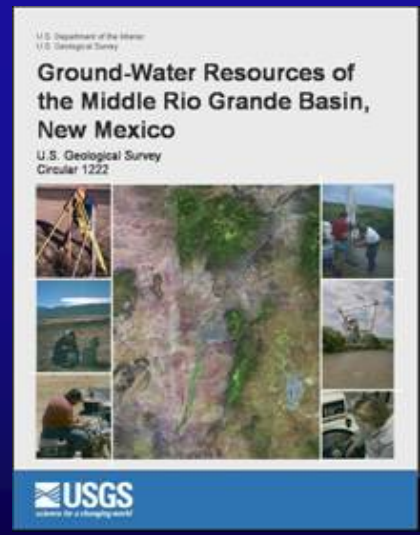


NUMA Cooperators – MRGB Study

- USGS New Mexico Water Science Center
- NM Office of the State Engineer
- NM Bureau of Geology and Mineral Resources
- Middle Rio Grande Council of Governments
- University of New Mexico – Earth Data Analysis Center







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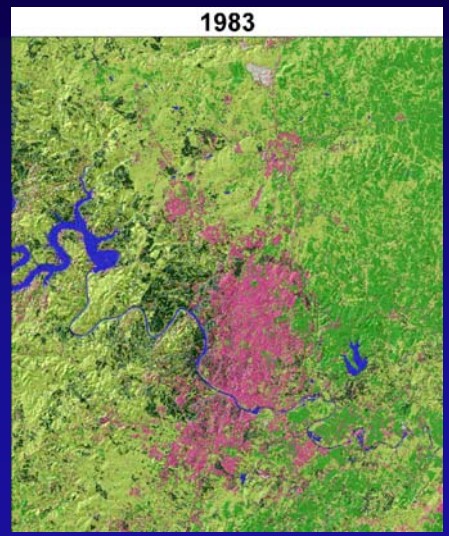
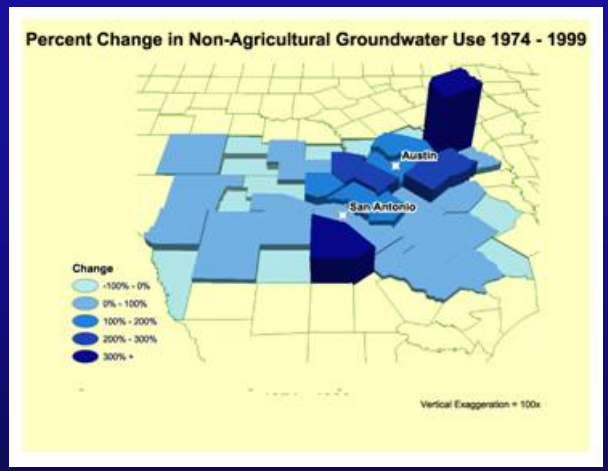
NUMA Partnerships: Edwards-Trinity

- USGS Water Resources Discipline – Austin & San Antonio
- University of Texas at Austin: Community & Regional Planning Department
- Greater Austin-San Antonio Corridor Council
- Texas Commission on Environmental Quality
- USGS Geologic Discipline





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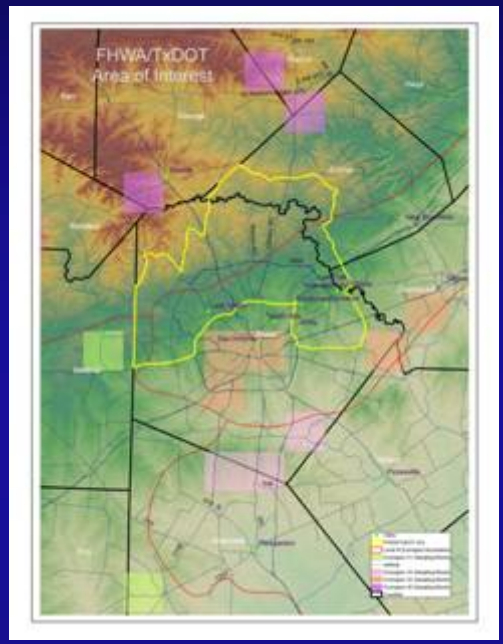
NUMA FY06 Customers/Clients

- **Federal Highways and Texas DOT**
  - San Antonio temporal LULC data distributed for US Highway 181/Loop 1604 Toll Road litigation
- **Capital Area Metropolitan Planning Organization**
  - Distributed Austin temporal LULC to assist 2035 Regional Plan's public urban growth visioning efforts



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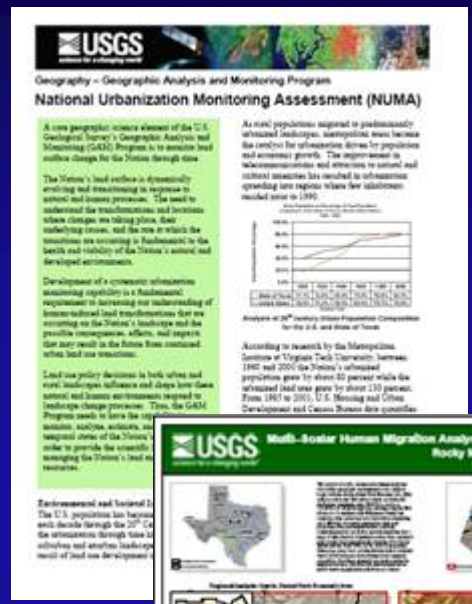
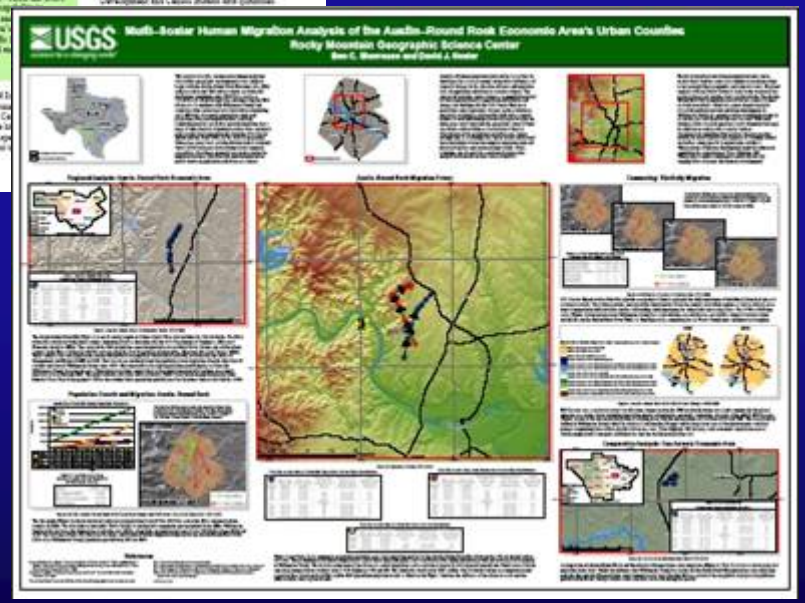
Publications

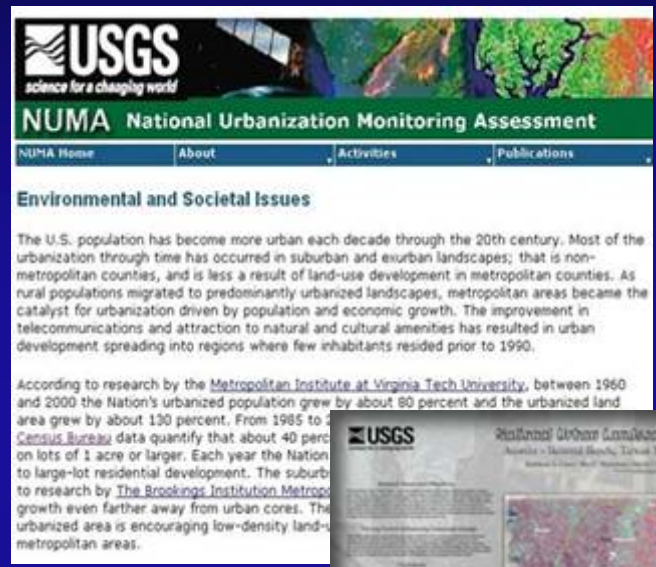
- USGS NUMA Factsheet (FS-2006-3040)
- Land Use Trend Analysis manuscript
- Human Migration poster

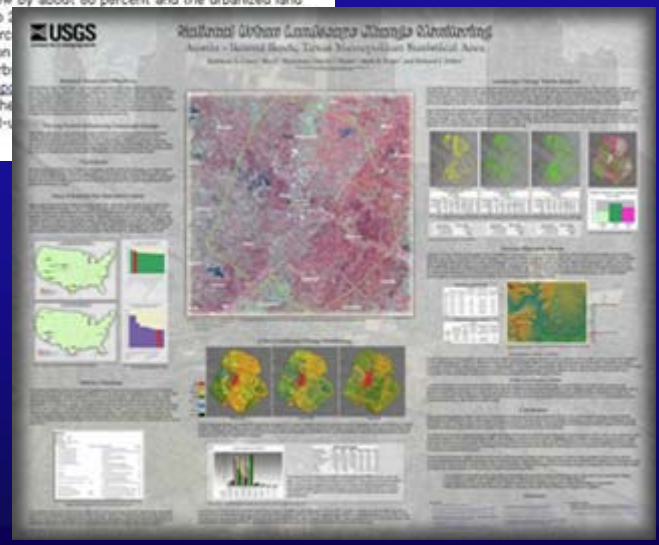




Outreach and Marketing

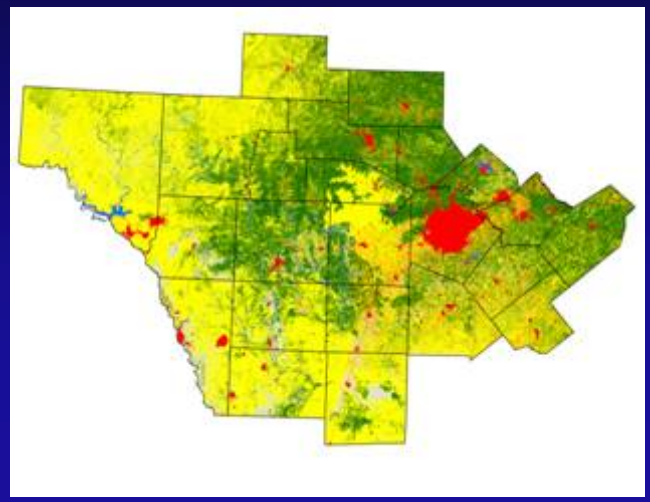
- Presented “Land Use Change in South Central Texas” at the FHWA Land Use & Transportation Planning Workshop
- USGS assistance provided to GAO “Urbanization, Agriculture, and Endangered Species Habitat” Study
- Developing DRAFT USGS NUMA website visualizing temporal urban landscape change

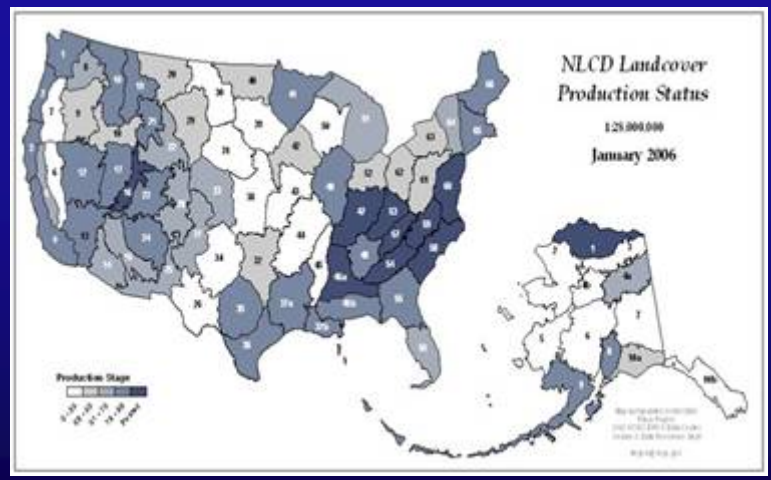




Land Use Trend Analysis Issues

- Vintage of Texas GAP LULC
  - USGS technical peer-review of NUMA temporal LULC data
  - Texas GAP data determined to be 1993 not 2003 as reported in the FGDC Metadata
  - GAP data deleted from NUMA land use trends research methodology
  - Recalculate temporal land use transitions and urban growth monitoring metrics





NUMA Project Timeline

- 3rd Quarter FY06 Plans
  - Human-Induced Land Transformations Analysis
    - Design population analysis module
  - Land Use Modeling
    - Generate Austin and San Antonio Economic Areas statistical landscape change estimates
    - Investigate implementing Urbanization Logical Data Model as a physical model for simulating landscape change within Economic Areas

NUMA Project Timeline

- FY07
  - Select (4) Economic Areas based on Gross Regional Product and Population rankings
  - Each Economic Area selected would be from a unique Core-Based Statistical Area tier and Economic Region

Economic Area	1977 to 2003 GRP and POP percent change	National Rank	CBSA Tier	Economic Region
Miami-Ft. Lauderdale-Miami Beach, FL	5.29%	13	Mega-Metropolitan	South Atlantic
Dallas-Fort Worth, TX	5.10%	18	Mega-Metropolitan	Southwest
Seattle-Tacoma-Olympia, WA	4.96%	24	Mega-Metropolitan	Far West
Sarasota-Bradenton-Venice, FL	6.90%	2	AAA-Metropolitan	South Atlantic
McAllen-Edinburg-Pharr, TX	5.61%	6	AAA-Metropolitan	Southwest
Colorado Springs, CO	5.40%	11	AAA-Metropolitan	Rocky Mountain
Reno-Sparks, NV	5.59%	7	AA-Metropolitan	Far West
Fayetteville-Springdale-Rogers, AR-MO	5.52%	8	AA-Metropolitan	Lower Mississippi
Boise City-Nampa, ID	5.02%	21	AA-Metropolitan	Rocky Mountain
Bend-Prineville, OR	5.51%	9	A-Metropolitan	Far West
Flagstaff, AZ	5.27%	14	A-Metropolitan	Southwest
Gainesville, FL	5.05%	19	A-Metropolitan	South Atlantic
Traverse City, MI	4.13%	54	Micropolitan	Great Lakes
Alpena, MI	3.93%	66	Micropolitan	Great Lakes
Twin Falls, ID	3.87%	69	Micropolitan	Rocky Mountain

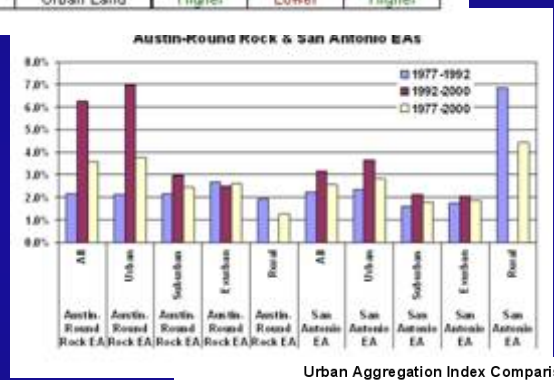
USGS

Economic Area Comparative Analysis

- Urban land growth rate exceeding urban population growth
- Urban growth occurring faster in exurban landscapes
- Majority of urban growth spreading into rural landscapes
- Process of urbanization and urban land patterns varies between Economic Areas

Table 3: San Antonio EA

RUCC Category	Growth Rate	Comparison Period A	B	C
All	Urban Population	Lower	Lower	Lower
	Urban Land	Higher	Higher	Higher
Urban	Urban Population	Lower	Lower	Lower
	Urban Land	Higher	Higher	Higher
Suburban	Urban Population	Lower	Lower	Lower
	Urban Land	Higher	Higher	Higher
Exurban	Urban Population	Lower	Lower	Lower
	Urban Land	Higher	Higher	Higher
Rural	Urban Population	Lower	Higher	Lower
	Urban Land	Higher	Lower	Higher



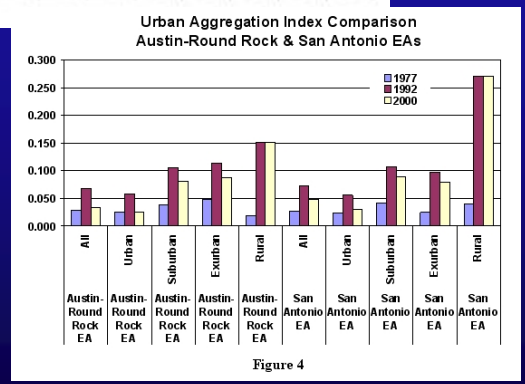
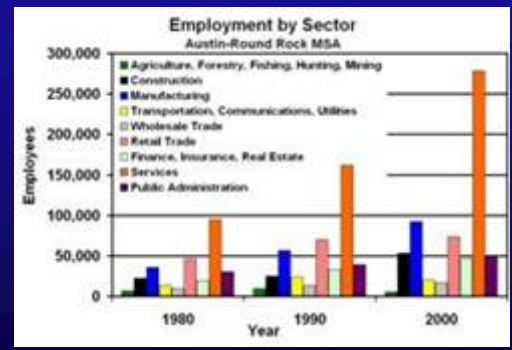


Figure 4

Conclusions – Future Urbanization

- San Antonio and Austin are southern anchors for I-35 Megapolitan corridor
- Peripheral urban expansion via Texas State Highway 130 and Trans-Texas Corridor
- Toyota manufacturing plant will support future economic growth for the San Antonio Economic Area
- Austin-Round Rock Metropolitan Statistical Area ranked #10 nationwide in high-tech growth (1990-1998)
- Austin & San Antonio Metropolitan Statistical Areas' population projected to increase from 2.8M in 2000 to 4.8M by 2040



Additional Information

- dhester@usgs.gov
  - (303) 202-4318
- RMGSC NUMA investigation
  - rockyitr.cr.usgs.gov/rmgsc/main/regionalMonitoring.htm
  - rockyweb.rocky.cr.usgs.gov/numa
- USGS Urbanization research
  - landcover.usgs.gov/urban/intro.asp
  - pubs.usgs.gov/circ/2004/circ1252/
  - landcover.usgs.gov/urban/info/factsht.pdf

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